

HEADS  
OF INQUIRY  
—  
LIGHTHOUSES.

Campbell 2. a 19

My dear Campbell

I send you a copy of  
"Heads in 'House' Inquiry"

too R advantage  
of your criticisms & my  
wish they had been

more numerous

Yours truly

Wm. P. Fyfe

Sample 12 n 19

December 18. 1863.

Receipt - well

J. H. Campbell

Recd. This seems  
to be the report &  
appendices of the Light-  
House Commission put  
into the form of questions  
and answers. But there  
is no one so far to put  
the questions or take the  
answers.

Campbell 2. 19

? Is there  
a change  
brewing in the  
management  
of dog houses.  
I have suspected  
it from other  
circumstances  
for some time

E. J. Admiral  
Hopes' questions  
put to me at  
Dessau.

What was my  
own opinion as  
to the management  
and so on.

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*H. Campbell Esq.*  
*with the complements and regards*

# HEADS OF ENQUIRY

INTO THE

## STATE AND CONDITION OF LIGHTHOUSES.

WITH

### EXPLANATORY NOTES,

FOR THE USE OF AUTHORITIES HAVING CHARGE OF LIGHTHOUSES, AND FOR  
THE INFORMATION OF LIGHTHOUSE KEEPERS, &c.

BY

ALFRED P. RYDER, CAPT., R.N., F.R.G.S..

LATE A MEMBER OF THE ROYAL COMMISSION ON LIGHTHOUSES.

*Decr. 1863.*

Much useful information regarding Lighthouses, their management, &c., was collected by the Royal Commission on Lighthouses, Buoys, and Beacons that reported in 1861. It has been thought advisable to arrange portions of it in a condensed shape.

The Heads of Enquiry can be made use of—

- (1) As an Inspection Report; in which case the blanks to the right of each page will have to be filled up.
- (2) As a collection of practical hints; when so treated the index will be found useful in guiding the reader to the information sought.

These sheets have been submitted to several persons, whose opinions on the superintendence of Lighthouses are entitled to the greatest respect, and their suggestions have been invariably followed. I am more particularly indebted to the Messrs. Stevenson.

A. P. R.

# HEADS OF ENQUIRY.

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1. Date of Visit.
2. Name and Rank of Inspecting Officer.
3. Name of Governing Authority.
4. Latitude and Longitude.
5. Name of Lighthouse.
6. From what fund erected ?
  - (b) Expense of erection of Lighthouse, stating whether inclusive or exclusive of lantern, of dwelling-houses, walls of enclosure, &c. If exclusive, give cost of lantern, of apparatus, of lamp.
  - (c) From what fund supported ?
  - (d) Annual expense of maintenance and repairs, including painting.
  - (e) If any charge on shipping, state its amount ?
7. Name of periodical Inspector.
  - (b) Intervals of Inspection.
  - (c) When last Inspected.
  - (d) To whom is report sent ?
8. Name of Designer of Lighthouse.
9. Name of Designer of Illuminating Apparatus.

## 10. Name of Constructor of Lighthouse.

## (b) Ditto of Illuminating Apparatus

The only constructors of Dioptric Illuminating Apparatus resident in Great Britain are Messrs. Chance, Birmingham. The best known constructors in France are Messrs. Sauter, Lepaute.

## (c) Ditto of Lamp.

## 11. Date of first exhibition of Light.

## 12. Height of Building from cowl or summit to ground.

## (b) Ditto of centre of Light above ground.

## (c) Ditto of ditto above high water, spring tide.

## (d) Rise and fall of spring tides.

## 13. Means of communicating with Head Quarters.

## (b) Time that must elapse before an answer, or aid can be sent.

## 14. Building of Lighthouse—

## (a) Material of.

## (b) If of Wood, what are the precautions against Fire ?

## (c) If of Iron, is there round exterior of base a filling of any sort, or a solid concrete surface to prevent water from settling so as to injure that part of the cast-iron plates which are under ground ?

## 15. Building of Lighthouse. Colour of.

## (a) Exterior.

## (b) Has it been selected with any view of identifying the Lighthouse, distinguishing it from other Lighthouses ?

NOTE.—Colour of Lighthouses should depend upon the background. *Ex.*—When a white Lighthouse has at its back a white cliff, it is of course indistinguishable. The white walls, out-houses, steps of the Lighthouse in contrast with grass or dark ground are very useful in pointing out the site of the Lighthouse at night and when the building above may be enveloped in fog.

16. *Building of Lighthouse.*—Foundation of.

Whether solid or made.

17. *Building of Lighthouse.*—Construction of.

Whether there is an exterior and interior tower, &c. ?

This is generally recommended on account of damp.

18. *Building of Lighthouse.*—Vibration of.

- (a) Does tower or lantern vibrate, in earthquakes or gales of wind ?
- (b) Has there been an earthquake, if so, when, and effects of ?
- (c) Are there any cracks, rents, settlements, or, if of iron, any separation of plates, rupture of rivet heads, &c. ?

19. *Building of Lighthouse.*—Ventilation of.

- (a) Is the building damp ?
- (b) Are windows kept open whenever it is advisable ?
- (c) Is the ventilation satisfactory ?

20. *Building of Lighthouse.*—Paint.

- (a) How often is it painted ?
- (b) When was it last painted ?
- (c) Is it painted by contract or otherwise, or by Keepers ?
- (d) Appearance of paint.
- (e) Description of paint used.

21. *Oil Store.*

- (a) Position ; (b) Capacity ; (c) State of ;
- (d) Precautions against fire ; (e) Is there a filter.

In France the oil that remains in the lamp is always filtered and then returned to the reservoir.

## 22. *Lightning Conductor.*

(a) Nature of.

Should be of copper.

(b) Is it in good order.

(c) Is there a supplying tank to conductor-tank in case of leakage.

(d) Has Lighthouse ever been struck, and with what effect?

(e) Is there much lightning.

## 23. *Spare Stores.*

(a) Obtain a list of.

(b) Are spare stores in good condition?

24. Is any other light of a Lighthouse or Light-vessel visible at night, and if so give its name, and state whether any irregularity in the appearance of the light that cannot be satisfactorily accounted for has been noticed, and when?

## ILLUMINATING APPARATUS.

### 25. *Nature of—*

Dioptric	{	In which the rays acted on are made parallel by being passed through glass and refracted, or refracted and reflected in the required direction (generally one lamp).
Catoptric	{	In which the rays acted on are reflected from metallic reflectors only (generally from 1 to 30 lamps).
Cata-dioptric	{	In which both a metallic and a glass-optical agent are employed, or, in other words, any union between the Dioptric and Catoptric systems (generally 1 lamp, but in Scotland often more numerous).
Holophotal	{	In which panels of totally reflecting prisms or holophotes are used in revolving and flashing lights, according to Mr. Thomas Stevenson's principle.

26. *Order of*, if Dioptric.

27. *Order of, or Number of Lamps*, if Catadioptric.

28. *Number of Lamps*, if Catoptric.

How are reflectors or holophotes, if more than one, disposed on the frame ?

29. *Character of*—

(a) Fixed ; (b) Flashing ; (c) Fixed and Flashing ; (d) Revolving ; (e) Intermittent ; (f) Alternating ; (g) two in same tower ; (h) two in separate towers ; (i) Fixed Red ; (k) Revolving Red and White ; (l) Revolving Red.

30. *Light*.—

Colour of, White, Red, or Green, &c.

NOTE.—Their relative visibility is in the following order:—White, Red, Green, Blue. White and Red are the only colours used when required to be seen at a distance. All coloured rays should be condensed when it is practicable.

31. *Are illuminated by*, in degrees—

(b) Compass bearings of extremes from lamp ;

(c) Are the rays in the dead angle rendered available by Stevenson's condensing apparatus or by spherical reflectors ?

If there are two houses, the lamps should vary in height above the sea a sufficient number of yards to prevent the rays of light from mingling and appearing, when in the same line, as a single light.

If the lights, when in the same line, are a leading mark, the nearest light should, when practicable, be the low light ; and if the channel is intricate the Lighthouses should be sufficiently far apart to show a marked change in the relative position of the lights when the vessel has made a small change in hers.

32. *Cover of Illuminating Apparatus* to protect it from the rays of the sun and dust, is there a ?

NOTE.—It should be of brown holland, and if there are reflectors they should always be covered immediately after they are cleaned.

33 *Machinery of Illuminating Apparatus, if any.*—

- (a) Note the state of the Bearings, for any appearance of friction.
- (b) Examine the Chain, or Rope, if revolving.

NOTE.—Wire or hemp rope is the best material.

- (c) The Weights; note if any have been added; this is a proof that friction had been found to increase; constant attention is necessary.

- (d) The Oil used for lubrication.

NOTE.—Ought to be olive.

- (e) The Rubbers.

NOTE.—Ought to be two, and should be kept carefully separate from the glass rubbers, which should be napkins, and the reflector rubbers, which should be of washleather. See the Instructions to Foreign Lights, appended. The rubbers are different for the different apparatus.

- (f) Enquire if any alterations have been made in machinery; by whom? why? with what result?
- (g) Enquire if any alterations are proposed in machinery; by whom? with what object? Lighthouse Keepers' opinion of them.

34. *Its Weight.*—How supported? On one or more standards?

35. *Its Frame.*—Diagonal or vertical?

36. *Its Glass.*—Is it clear and free of veins?

37. *Light, how obtained.*—

- (a) By electricity.
- (b) By oxy-hydrogen on chalk.
- (c) By coal or other gas.
- (d) By oil, and, if so—
- (e) By what oil—colza, spermaceti, coconut, seal, &c.?



38. *If Oil is used.*—

- (a) State its appearance ;
- (b) Where kept ?
- (c) In what receptacles ?
- (d) Is there a filter in use ?
- (e) Is refuse oil filtered ? or mixed every day with the fresh oil ? or thrown away !
- (f) Does the oil become thick in cold weather ?
- (g) Is it necessary to heat it ; and, if so, how is this done ?

NOTE.—The mechanical lamp always heats its own oil.

- (h) What is the quantity always maintained in store ?

NOTE.—There should always be three months' stock in store to allow it to clarify, and this quantity should be increased in rock lighthouses.

- (i) Are keepers allowed to make use of the oil for domestic purposes, and, if so, is there any check on the quantity ?
- (k) Have keepers noticed any difference in the oil within the last three years, if so, state its nature ?
- (l) How is consumption of oil measured for the Register ? Do accounts of successive years agree ?

In France a delicately graduated metal rod is placed in the lamp every hour or watch, and height of oil carefully registered. The keepers are encouraged to maintain the highest possible consumption of oil.

- (m) How much oil was expended in each month for last three years ?

An Argand burner, 1-inch diameter, is found in Northern Lighthouses to consume annually 40 gallons.

A first class dioptric fountain lamp, of the ordinary construction, burns about 450 } gallons  
Ditto ditto mechanical lamp burns 740 to 800 } per year.

The amount of oil burnt is, as a general rule, a fair criterion of the efficiency of the light. No first class dioptric apparatus can perform its duty properly with a less annual consumption than from 740 to 800 gallons of colza oil.

- (n) Price of oil.

39. *Time of Lighting and Extinguishing.*—

Is it strictly adhered to ?

NOTE.—A Table showing the time for each day is hung up in Scotch Lighthouses. It is calculated for each site. In the northern Lighthouses, having a long twilight, the lamp is not lit at sunset, or allowed to burn till sunrise, as in the more southern Lighthouses, and a considerable economy is thus effected.

40. *Number of hours lamp has been lit during the year.*41. *Has the lamp been extinguished by accident or neglect.*

(a) How often in last three years ?

(b) Date of.

(c) Effect of.

NOTE.—Messrs. Chance always fit an oil reservoir to, and above, their large mechanical lamps, so that the light may be left burning as a fountain lamp should any accident happen to the machinery.

42. *Repair of Accidents to Illuminating Apparatus.*

(a) Is Chief Keeper competent to undertake the duty ?

(b) Have any been undertaken ?

(c) By whose orders ?

(d) Nature of accident.

(e) By whom repaired ?

(f) Was it sufficiently well executed ?

43. *Lantern.*—

(a) Description of.

Gallery of Lantern.—

(a) State of repair.

44. *Glass of Lantern.*—

(a) State of, as to cleanliness.

(b) State of, as to repairs.

(c) How many spare panes ?

In the northern Lighthouses there are what are called "Storm panes." They are panes fitted with a frame of copper, which can at once be attached by screws to the lantern in the event of a pane being broken in a gale or by birds.

(d) Are there any scratches on the glass ?

If so, probably caused by scratching paint drops with a knife, instead of wiping them off with a sponge.

(e) Are there any internal curtains ?

Their object is to protect the interior of the lantern from the effects of the heat, which, causing inequality of expansion of the metal, will chip the glass of the illuminating apparatus. The curtains should be hung up immediately the lamp is extinguished in the morning, as the rays of the rising sun have been known to re-illuminate the lamp. Brown holland has been found well suited for the purpose.

(f) Is the glass of lantern clear, colourless, free from veins? and is it of even thickness, so as not to bend light upwards or downwards ?

(g) Is the framework of lantern as slight as is consistent with safety, so as to intercept as few as possible of the rays ?

(h) Are the astragals vertical or slanting ?

Large and massive frames have sometimes been noticed to be so constructed as to materially interfere with the efficiency of the light.

#### 45. Colour of Interior of Lantern.

(a) What is the colour of ?

The colour of interior of roof and sash-bars should be white; lantern-plates, light Prussian blue; stonework should be painted stone colour; floor, Spanish brown (on account of oil stains). The floors of northern Lighthouses are covered with oil cloth. All paint should be ZINC. Brass work should be bronzed, not kept bright, as oil, brickdust, and friction are all objectionable.

#### 46. Cowl of Lantern.

(a) Is there a cowl ?

(b) Does it freely revolve with the wind ?

(c) Has it crossbars ?

Lamps have been extinguished and entirely destroyed by birds finding an entrance down the cowl into the lantern.

#### 47. Ventilation of Lantern.—

(a) Is it good ?

The symptoms of imperfect ventilation are dark sooty roof.

In first class Lighthouses the ventilation is obtained by numerous grated air-holes, with sliding plates in wall of lantern. The obtaining it by the door only is very objectionable, as the draught must be irregular; but if by door there should be two of them.

- (b) Is there a metal chimney continuous to cowl over each glass chimney?

This is essential to perfect ventilation.

- (c) If lamp is dioptric, is the metal chimney fitted with Faraday's openings to pre-vent downward draught?

If so, lower opening may in some cases be closed and flame raised by the resulting increased draught.

#### 48. *Lamp or Lamps.*

- (a) Nature of.

Electric	{	1	{	Electric currents evolved by aid of revolving magnets worked by engine, as patented by P. Holmes.
		2	{	Electric current evolved by aid of batteries.
Oxy-Hydrogen	{	Two streams of Oxygen and Hydrogen on chalk.		

The Dioptric, Catadioptric, and Holophote have generally	{	<i>Pump—</i> In use in France and Scotland: one or more small pumps force up from a reservoir a continuous and copious supply of oil from two to three times as much as is consumed. This keeps the wick cool and produces a high and brilliant flame. The oil in the reservoir is kept warm by the constant return to it of warm oil.		
		<i>Moderator—</i> In use in France: a heavy piston descending forces up a copious supply of oil, as in the pump lamp.		
		<i>The ordinary Fountain.</i> The ordinary fountain lamp in use in England and Ireland forces very little more oil over the wick than is consumed.		
		The new fountain lamp, as fitted by the Trinity House in 1862, which is said to answer well.		

A Catoptric illuminating apparatus has generally the ordinary argand lamp or lamps.

These lamps are fitted with silvered reflectors. The lamps may vary in numbers from one to thirty, as in the Lighthouse at Beachy Head, but all new fixed Lighthouses should be Dioptric. Drip cups should be attached, and the lamps should be fitted so that they can be removed without unhooking reflectors.

In the proximity of towns gas is sometimes used: the best description of burner is the argand; the products of combustion should be carefully conveyed away in chimneys over the burner to prevent the deposits of soot.

It is probable that every different description of lamp requires a different amount of ventilation. Mr. Darrell, the intelligent Lighthouse-Keeper at Bermuda, informs me that when they changed from sperm to colza, he had to ask for new chimneys with larger openings below.

(h) Number of lamps. How many spare lamps?

(c) Is lamp perfectly clean and in good order?

Method of cleaning recommended is as follows:—

(See Directions for Keepers at end, supplied by D. and T. Stevenson, Esqrs., the Lighthouse Engineers at Edinburgh.)

(e) Are lamps and reflectors covered after they have been cleaned, to prevent deposits of dust?

(f) Chimneys.—Shape of.

If the chimney has an abrupt shoulder the rays of light will be obstructed in passing through it, and diverted from the horizon. The shoulder should change its angle gradually. (See Plate, at end.)

(g) Size of base of chimney.

The amount of oil consumed depends upon the amount of air supplied to it. An increased area in the base of the chimney has been found to be an improvement.

(h) How many chimneys broken per lamp, per twelvemonth?

If they are properly made and selected, the secret of breaking few chimneys is—

(a) Raising the flame and extinguishing it VERY GRADUALLY.

(b) Care in cleaning the chimneys. If they are moist when the lamp is lit they are sure to break.

(c) Proper instruments for holding and cleaning the chimneys, viz., holders, covered with leather.

(d) Absence of irregular draught in lantern.

In Lighthouses under the Scotch Board the average annual breakage of chimneys is—

For Single Argand burner .. ..	3½ Chimneys.
„ Two-wick .. ..	4 „
„ Three-wick .. ..	12 „
„ Four-wick .. ..	12 „

Where keepers understand their duties well, and keep a constant high steady flame, the same chimney has been known to last for several years.

#### 49. Signals—

##### Fog Signals.

(a) Are there any? for the purpose of pointing out the position of the Light-house to passing ships.

(b) If any, describe them.

Guns; bells rung by machinery; gongs; whistles, screamers have been suggested and tried.

Guns fired, at stated and fixed intervals are generally considered to be the best fog signal. But unless the interval is carefully attended to the signal may be mistaken for one

from a ship in distress. Fifteen minutes would be a sufficient interval.

As steamers always whistle in a fog, the whistle is evidently inappropriate for a fog signal from a *Lighthouse* unless some marked distinction can be given to it.

Reflectors have been placed behind bells to intensify the sound in the required direction. Gongs easily crack; the weather affects them, and they are probably struck too hard.

A gun fitted with an apparatus over the vent in the shape of a whistle might make a very distinctive fog signal.

(c) Are fogs frequent?

(d) How many hours of thick fog, on an average in 12 months?

#### 50. *Tide Signals.*—

Are there any? For the purpose of communicating to ships the time of tide, the height of water on the bar, &c.

Tide signals are of great importance; at some harbours they have been made self-regulating, worked by a float.

Tide signals at night are not uncommonly communicated by exhibiting a separate light (red, green, or blue, if principal light is white), whenever the depth of the water is above or below a certain depth. In Scotland, red is considered to be generally a danger signal.

#### 51. *Electric Telegraph Signals.*—

Are there any? To inland authorities, neighbouring lighthouses, &c.

In France there is a complete chain of electric telegraph, so that every Lighthouse can be communicated with by day and night. Screens moved at intervals on land side afford the means of making a few signals.

#### 52. *Signals by Semaphore, or flags to passing ships.*—

Are there any?

In France every Lighthouse can communicate by a code to passing ships.

#### 53. *Internal Signals.*—

Are there any? For calling other Keepers by day or night.

In Scotland, there are bells and voice tubes, from lantern to dwelling-houses.

#### 54. *Wrecks.*—

(a) List of, in neighbourhood within last ten years.

(b) Probable cause of wrecks.

(c) Are there any life-boats?

(d) Are there any other means of aiding the crew to escape from the wreck, such as single or double rockets or mortar apparatus?

NOTE.—It has been stated in the evidence of Mr. Napier that the Head Keeper of one of the colonial Lighthouses owned, or had, a pecuniary interest in (some) wrecking vessels, and that the Lighthouse under his charge had been observed to be occasionally unlit at night.

#### 55. *Instruments.*—

(a) Are there any, and if so, what?

There should be a barometer, a thermometer, a clock, a sun-dial, a rain gauge (placed so as not to project above level of ground), a compass.

#### *Meteorological Observations.*—

(a) Are any registered?

(b) To whom are the records forwarded?

There should be one universal form, and the observations should be regularly registered and sent to the Meteorological Department of the Board of Trade.

#### 56. *General Cleanliness.*—

(a) State of.

Carefully examine store rooms, oil room, lantern, &c., inviting Keeper to open all drawers and cupboard doors. Carefully examine all iron work in gallery, &c., to see if any rust is allowed to accumulate. If any rust has accumulated it should be removed, and a coating of anti-corrosive paint put on first. If there is no anti-corrosive paint, &c., mix powdered red lead with zinc (white) as a priming; where there are crevices a mixture of paint, oil, and turpentine should be used. Then coat all over with white zinc paint. In painting sash bars great pains should be taken not to spot the windows, and if any spots are made, a large sponge free of grit should be used to remove them (not a knife).

(b) Note how burners are cleaned, and if the points of the scissors are used, and recommend that a knife should be procured and reserved for the purpose.

#### 57. *General Orderliness.*—

(a) Note order in which spare gear is stowed and kept.

(b) Look at account-books; are they neatly and correctly kept?

(c) How soon can spare lamp be substituted for lamp in use? Ask for it to be shifted, and note time.

- (d) If illuminating apparatus revolves, how soon can chain or rope be replaced. See it replaced, and note interval.

58. *Water for Drinking.*—

- (a) Whence obtained.  
 (b) If rain-water, where is it kept? If in a tank, its capacity?  
 (c) Is there a filter?

59. *Medicine Chest and Attendance.*

- (a) Is any supplied?  
 (b) How near is medical attendant?  
 (c) Are his visits charged to authorities or to Keepers?

60. *Sanitary Condition of Keepers and Family.*

- (a) Is the situation considered to be healthy?  
 (b) If not, what complaints are common?  
 (c) How are they most successfully treated?

61. *Neighbourhood.*

- a) Name of nearest town, village, or dwelling-house.  
 (b) Distance from it.  
 (c) Means of communication with it.  
 (d) Frequency of communication.  
 (e) What facilities have Keepers for supplying themselves with groceries, &c.

62. *Education of Keepers.*

- (a) Are Keepers intelligent?  
 (b) Do they write a clear legible hand?  
 (c) Is there any school for their children, and at what distance?  
 (d) Are the Keepers, on first starting, instructed in their work, and if so, by whom? For how long? Nature of examination.



63. *Library.*

- (a) Are the keepers supplied with a library?
- (b) Is it changed periodically?
- (c) Have they any book on Lighthouse management?

NOTE.—The Scotch Keepers are regularly supplied with the “Illustrated London News” by the Scotch Lighthouse Board, in addition to a small library, which is changed periodically.

64. *Keepers.*

- (a) Names of.
- (b) Ages.
- (c) Years at Lighthouse.
- (d) Years of previous service, and where?
- (e) Previous trade or occupation.
- (f) Are they allowed to follow any trade, if so, what?
- (g) Pay and allowances.
- (h) Grazing land, garden, &c.
- (i) Any perquisites other than their salary?
- (k) Married? Number of children?
- (l) Pension or superannuation, amount, and at what age granted?
- (m) Has Light ever been temporarily entrusted to any one except an authorised keeper? If so, when? why? and for how long?

65. *Dwelling-houses.*

- (a) Nature and extent of accommodation: cubic contents in feet per keeper; number of bedrooms, &c.
- (b) Materials of which houses are constructed?
- (c) Precaution against fire.
- (d) Cleanliness. Order.
- (e) Distance from Lighthouse.
- (f) State of road.

- (g) Is Lighthouse in sight from dwelling-houses?
- (h) What means of communicating between them?

#### 66. *Tools.*—

- (a) Are they complete and in good order?
- (b) They should consist of.

NOTE.—The following list has been kindly supplied by Messrs. Stevenson, it is extracted from a recent specification by them for a First Class Mechanical Lamp:—2 spar-polished steel chains for machines, 1 brass Liverpool lamp, 1 strong copper chimney from top of glass chimney to top of apparatus with damper, 1 gun-metal presser for making pump leathers, 6 steel valve and washer punches, 1 set of trimming mandrils, 2 pair brass lifters for broken glass, 2 pair of tongs for glass chimneys, 2 pair glass lifters, 2 trimming hooks, 1 pair trimming shears, 1 brass case to hold spare glasses, 1 frost lamp, 1 spirit level, 1 pair steel coupling plyers, 1 nut key, 2 screw drivers, 2 sash tools, 1 dust brush, 1 chamois skin, 1 calf skin, 1 kid skin, 1 oil pot.

#### 67. *Birds.*—

- (a) What birds are most frequently seen in neighbourhood of Lighthouse?
- (b) Do they ever fly against and break the panes?
- (c) At what months of the year do they appear and leave?

#### 68. *Fish.*—

- (a) Are any fish caught in neighbourhood of Lighthouse, and if so, of what description?
- (b) In what quantities?
- (c) In what months?

#### 69. *Boats.*—

- (a) Are Keepers allowed to keep or use a boat for fishing or excursions?
- (b) Have they a boat of any kind?
- (c) If so, have they ever been detained from the Lighthouse at night?

## 70. *Stores—Oil, &c.*

- (a) How are they supplied?
- (b) If by periodical visits of vessels, state particularly description of vessel, interval of visits, &c.
- (c) How are they procured? By open contracts?

## 71. *Evidence of Efficiency of Light.*

(a) Give any trustworthy evidence of efficiency of light, or of its want of efficiency, whether owing to inherent defects in the illuminating apparatus or lamp, &c., or to want of attention on the part of the Keepers.

(b) Recommend to Government authorities that every precaution be taken to constantly note the state of the light. The only security that the Keepers are constantly on the alert, and maintaining the flame at its proper height, is a knowledge on their part that the light is watched and reported on.

(c) In the case of a revolving light any neglect of the height of the flame, by which it is lowered, will betray itself by the flash not being seen so near to the Lighthouse as it should be when the flame is at its proper height. A very slight diminution in the height of the flame will make a difference of miles in the range of sea or land illuminated by the flash.

(d) To a ship approaching a Revolving Lighthouse in thick weather this is of great importance, as if the flame is low, and the usual limit of the flash's visibility near the Lighthouse is thus thrust out to seaward, the ship may not, owing to the weather, obtain sight of the light until within this limit, when the light, instead of showing as a revolving light, will show as a dull fixed light. In such a case a look-out man aloft might be the only person who could see the flash, whereas it ought to have been seen from the deck; this might lead to very dangerous mistakes as to its distance, and even as to its identity. N.B. This was the case at and within a distance of five miles from a first-class Dioptric Revolving Light lately visited by me. The flash was not reached by the look-out man until he had ascended the rigging 80 feet above the water. This was corrected by slightly raising the lamp, and maintaining a higher flame.

(e) Keepers in charge of dioptric illuminating apparatus, should be impressed, therefore, with the great importance of maintaining the normal flame AT ALL TIMES, because the higher the flame the more rays are sent forth to the horizon, BUT MORE PARTICULARLY IN THICK WEATHER, because the *near* sea is especially and mainly dependent upon the *upper* portion of the flame for its illumination.

## 72. *Flame.*

- (a) Is there hanging-up in the Lighthouse a printed drawing of the flame that ought to be maintained?

This is the practice in all Scotch Lighthouses, and is of

great service in aiding the Keepers to maintain the flame at its proper height.

No lamp in first or second order Lighthouses ought to be used in which the flame cannot be maintained at, at least,  $2\frac{1}{2}$  to 3 inches in height. It is to be feared, however, that with an *ordinary* fountain lamp no flame of 2 inches height can ever be maintained.

The *First Order Dioptric* light, with a *mechanical* or pressure lamp, should have a flame at least  $3\frac{1}{2}$  inches high.

The height of flame attained by the improved fountain lamp is believed to be over 3 inches.

### 73. Night Watches.

(a) How are they kept?

Where there are less than two Keepers it is impossible but that the lamp must be unwatched for hours, and three are not too many when the night is over ten hours long.

### 74. Night Inspection.

(a) Is the Lighthouse ever inspected at night without warning?

(b) How often? by whom?

(c) The only points which a Night Inspector need be careful to note, are the height of the flame, which should be measured and registered; also its appearance as to colour, clearness, &c., and the state of cleanliness of the lenses and lantern glass; the interval of revolution if the light revolves; and the alertness or otherwise of the keepers. The Night Inspector should have a latch key.

OUTLINE OF FLAMES

MAINTAINED IN

SCOTCH LIGHT-HOUSES.

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MESSRS. D. & T. STEVENSON, OF EDINBURGH,

ENGINEERS.

N<sup>o</sup> I.

FLAME  
OF A  
FOUR-WICK LAMP

FULL SIZE

Note The burner is in correct adjustment when Threads stretched from the marks on the Apparatus Frame pass over its centre, just touching its upper surface

FLAMES FED BY  
FORCE PUMPS.

STRETCHED

Consumption of Gas Oil

Per Hour Galls	Per Year Galls
6.72	794

N<sup>o</sup> III

FLAME  
OF A  
TWO-WICK LAMP

FULL SIZE

FLAMES FED BY  
FOUNTAINS

Consumption of Gas Oil

Per Hour Galls	Per Year Galls
1.78	210

Nº II

FLAME  
OF A  
THREE-WICK LAMP

FULL SIZE

*Note. The Burner is in correct adjustment when Threads stretched from the marks on the Apparatus-Frame pass over its centre, just touching its upper surface.*

FLAMES FED BY  
FORCE PUMPS.

ETCHED THREAD

<i>Consumption of Colza Oil</i>	
<i>Per Hour</i>	<i>Per Year</i>
<i>Ozls</i>	<i>Ozls</i>
5 13	371

Nº IV.

FLAME  
OF AN  
ARCAND BURNER

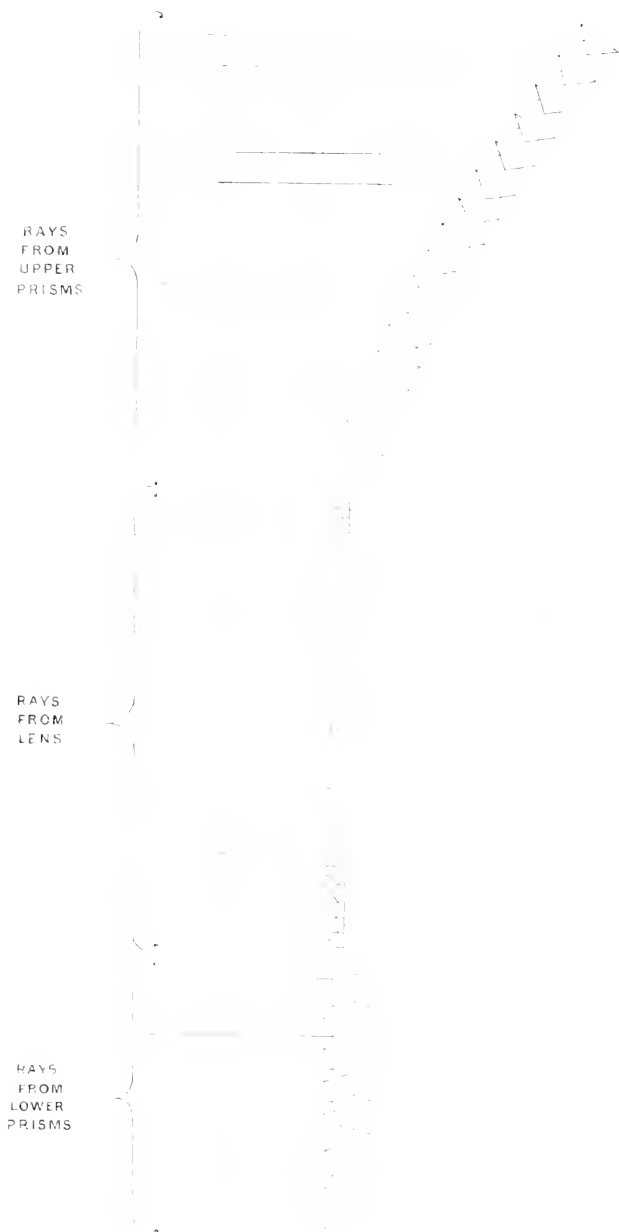
FULL SIZE

FLAMES FED BY  
FOUNTAINS

<i>Consumption of Colza Oil</i>	
<i>Per Hour</i>	<i>Per Year</i>
<i>Ozls</i>	<i>Ozls</i>
0-31	10

SKETCH OF A DIOPTRIC ILLUMINATING APPARATUS 1ST ORDER FIXED OR REVOLVING.  
SHOWING THE POSITIONS OF THE FOCI FOR THE LENSES AND PRISMS AS  
ADJUSTED BY THE MESSRS CHANCE, IN AN ILLUMINATING APPARATUS LATELY  
SUPPLIED BY THEM

NB THE BURNER IS PLACED IN ITS NORMAL POSITION VIZ 1 IN BELOW THE CENTRAL FOCUS OF THE LENSE

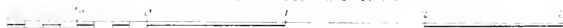


*The focus of the upper prism  
is 1.3 inch above burner  
and .5 inch behind Vert. Axis  
The focus of lower prisms  
is .9 inch above burner  
and 1.6 inch before Vert.  
ical Axis.*



*Flame  
Burner*

Scale an inch to a foot





## 75. DIRECTIONS FOR THE KEEPERS OF LIGHTHOUSES.

*Introduced by Permission of the Messrs. Stevenson.*

(a) Great care should be bestowed in keeping everything connected with a Lighthouse in proper efficiency; the optical apparatus, consisting of reflectors, lenses, or prisms, suffers materially from the effect of dust in injuring its polish, and the proper burning of the lamps is impaired by a want of due attention to their cleanliness and the state of the wicks.

The following general directions may be found useful:—

(b) *Metallic Reflectors.*—In Lighthouses where metallic reflectors are employed, they should always be carefully dusted with a feather or fine brush before being burnished; and particular care should be taken that the chamois skins used in rubbing them be perfectly free from dust or gritty particles. Without such precautions the cleansing process will only tend to scratch the reflectors.

(c) The great art of keeping reflectors clean consists in the daily, patient, and skilful application of manual labour in rubbing their surfaces, beginning at the centre, and gradually working outwards with a circular motion of the hand. No damp or wet substance should ever be applied to metallic reflectors. If their lustre becomes dim, a little prepared rouge, of the finest description, in the state of an impalpable powder, may be employed on the chamois skin as a polisher.

(d) If spare metallic reflectors have long lain unused, and have consequently become covered with a thick and dark coating of oxide, rouge mixed with oil may first be applied to remove the film of oxide; after which, dry rouge should be dusted on, and the reflector polished in the usual manner with a dry and soft chamois skin.

(e) *Glass Lenses or Prisms.*—In Lighthouses where glass lenses or prisms are used, they should be cleaned every day, being first freed from dust by a feather or other soft brush, and then rubbed with a soft chamois skin free from anything that would injure the polish of the glass. If the glass becomes greasy, it should first be washed with a linen cloth steeped in spirit of wine, thereafter carefully dried with a soft and dry linen rubber free from all dust or gritty particles, and finally rubbed with a fine chamois skin. The rubbers used for the glasswork must also be free from grease. It may sometimes be necessary to use a little fine rouge with a chamois skin for restoring any deficiency of polish which may occur; but in well-managed dioptric Lighthouses this application will seldom be necessary.

(f) *Lamps.*—The brass work of the lamps is to be kept clean by polishing with fine rotten-stone. Great care should be taken that the lamps are accurately in the focus of the illuminating apparatus, and that the flow of oil is such that a proper height of flame is maintained in conformity with the diagram, which should be framed and hung up in the Light-room. If the flame cannot be maintained to the standard height, the Keeper should immediately examine whether or not this is due to want of cleanliness of the burner, want of proper flow of oil, or any imperfection in the wicks or oil, or the draft of the lamp chimney. The wicks should be *gradually* raised, during the first twenty minutes of burning, to the level of  $\frac{1}{4}$  inch above the burners—a height which should not be exceeded. In argand lamps the oil should be turned on ten minutes before the time of lighting; and to prevent overflow it should be turned off ten

minutes before the time of extinguishing. These argand lamps are generally trimmed once during the night, when colza oil is used; but they require it oftener with sperm. A sinking of the flame is the indication that it is required.

(g) The compound wick mechanical lamps being all constructed to give a plentiful overflow (from three to four times the quantity consumed), the wicks char but slowly, and the lamp should burn when in good order the whole night without the wicks requiring to be touched when colza oil is used. When, however, the flame is seen to be sinking, the lamp must be trimmed. This is done by the trimming-hooks, which are passed up the air spaces of the burner, and used to knock off and pick out the charred wick piecemeal. In all cases where the apparatus is illuminated by a single central burner, a spare burner, trimmed and ready for lighting, should be kept in the lightroom, with coupling-plyers, so that it may at once be applied should anything go wrong with the burner, and the Liverpool or temporary lamp should also be kept trimmed and in good burning order, in case anything should interrupt the working of the pumps. In preparing the wicks for lighting, they must be kept perfectly smooth and level; and after being used a night, the charred part must be cut away before they are relit.

(h) In making new pump-leathers for the mechanical lamp, the following directions must be attended to:—Before placing the skin in the press, cut a piece  $10\frac{1}{2}$  by  $3\frac{1}{2}$  inches, and steep it in colza oil for an hour. Then, after cleaning it by a light rub on both sides with cotton waste, press it in the usual manner, taking care to punch it accurately for the screws of the press. Bring down the press very slowly and equally all over—not less time than one hour should be taken to bring down the press; thereafter the skin should be allowed to remain one hour in the press before it is finally placed in the chambers.

(i) *Machinery.*—In all Lighthouses where machinery is employed to propel revolving lights, or to work mechanical lamps, it should be kept scrupulously clean, and all working surfaces should be regularly and carefully oiled.

(k) If the machine does not go well, and there is no very obvious cause, it will generally be found that the end of the fly-shaft or its footstep is “cutting.” The footsteps are easily shifted, and the fly-shaft can generally be smoothed on the oil-stone; but if it be much injured, the spare one should be put in and the damaged one sent to a proper workman.

(l) *Windows.*—The windows of the lantern should be regularly cleaned every day, and washed with water when necessary, to remove sea-spray or other obstructions to the passage of the light, and for the same reason they should be rubbed during the night when they become obscured by condensation or “sweating.” The Keepers should take care, by opening doors or otherwise, to admit a sufficient supply of air to insure the proper burning of the lights and prevent condensation. The storm-panes should always be kept in readiness for immediate use, in case of accident.

D. & T. STEVENSON,

*Civil Engineers, Edinburgh.*

## OPTICAL PORTION OF INSPECTION OF LIGHTHOUSES.

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### I. *Requisites.*

- (1) String : (2) Foot-rule (ivory, graduated decimally); (3) Small level;  
(4) Focus indicator.

A small instrument designed by Mr. Faraday to enable the exact position of the focus of a lens above the burner to be measured, but a card will answer the same purpose.

The focus may be too near the glass, or too far from it, for the position of the lamp; and the image of the sea horizon may be found too low or too high with reference to the flame.

- (5) Compasses; (6) MS. Book; (7) Plumb line; (8.) Pocket Compass.

### II. Take off chimney and screw up wicks.

(a) If the wick has not been cut since the lamp was extinguished, note if there is an excessive depth of charr, which is an indication of an insufficient amount of overflow. Enquire how often the lamp is trimmed during the night.

(b) The French and Scotch keepers, owing to the great overflow from their mechanical lamps keeping the wick cool and uncharred, never trim their lamps during the night.

(c) The overflow of oil is from twice to three times as much as is consumed.

### III. Light lamp; replace chimney.

(a) Keep the wick low at first, and allow the lamp twenty minutes to burn up, during which time answers can be obtained to questions.

(b) When the flame is in its normal state, measure the height of the flame above the burner, top of wick above burner, top of flame spikes above burner, and register them.

(c) The top of the flame should never be allowed to burn red, as smoke is the result.

(d) The management of the flame so that it shall constantly burn bright, clear, high, and in so doing consume its maximum amount of oil, is the most important part of a Keeper's duties, and requires considerable experience and constant care and attention, even with well constructed apparatus.

### IV. Extinguish lamp and screw wick up again to position when lighted.

### V. Ascertain position of focus in reference to burner.

(a) The position on a vertical line (above the burner) of the brightest horizontal section of a flame varies in different flames, but is at the same height in the same lamp when the flame is at the same height. The lenses should be so adjusted that the sea horizon focus of each of them is at the bottom of this brightest section. It is necessary to distinguish between the central focus which sends out parallel rays at right angles to the plane of the lens, and the sea-horizon focus, which is found on a line inclining to the lens at an angle equal to the complement of the dip.

(b) If the light revolves, ascertain centre of two opposite lenses, and, if light is fixed, the centre of two opposite lenticular panels, and stretch a line across from one to the other; repeat this at right angles. The point of intersection should be the common central focus of the lenses; note the distance of this above the burner. To facilitate this there should be four small metal eye-bolts permanently attached to frame; the intersection of two cross lines attached to them should be the common central focus. In Scotch Lighthouses these eye-bolts are so placed that the intersection of the lines mark the position at which the centre of top of burner is to be maintained.

(c) The burner, from frequent cleaning and scraping, will always be losing in *height*, and therefore depressing the flame in respect of the foci of the lenses. This can only be effectually remedied by gradually raising the lamp, maintaining the proper distance between the focus and the burner with great care.

(d) TABLE I.

THE NORMAL DISTANCE THAT THE BURNER SHOULD BE BELOW THE CENTRAL FOCUS.

Orders.	At Home, under careful Superintendence of experienced Keepers.		Abroad, if constant careful Superintendence cannot be obtained.	
1st Order .. ..	1	2 in.	1	1 in.
2nd ditto .. ..	1	1	1	0
3rd ditto .. ..	1	0	0	9
Argand Fountain..	0	9	0	7

(e) The necessity of adjusting lamps for Lighthouses abroad by the second column in Table I, arises from the difficulty which has been experienced in securing the services of men who will pay constant attention throughout a long night to maintain the flame at its maximum height. Under such circumstances the distances in the second column must be used for safety to diminish the risk of the flame dropping below the focus, and practically becoming almost extinct by sending nearly all its most important rays to the sky. The Messrs. Chance adjust their lamps by the second Table, if the light is to be elevated over 100 feet above the sea (see Table II).

TABLE II.

CORRECTION OF POSITION OF LAMP FOR DIP OF SEA-HORIZON, WHEN THE LATTER IS CONSIDERABLE.

Table II. gives the height that the lamp must be raised above its normal position (owing to the dip of the sea-horizon) when the light is 100 feet and over above the sea.

Height of Light above the Sea, in feet.	Order of Illuminating Apparatus.					
	First.		Second.		Third.	
	Millimètres.	Inches.	Millimètres.	Inches.	Millimètres.	Inches.
100	2.608	0.10	1.984	0.08	1.418	0.06
120	2.857	0.11	2.174	0.09	1.553	0.06
140	3.086	0.12	2.348	0.09	1.677	0.07
160	3.299	0.13	2.510	0.1	1.793	0.07
180	3.499	0.14	2.662	0.11	1.902	0.08
200	3.688	0.15	2.806	0.11	2.001	0.08
220	3.868	0.15	2.943	0.12	2.102	0.08
240	4.040	0.16	3.074	0.12	2.196	0.09
260	4.205	0.17	3.199	0.13	2.285	0.09
280	4.364	0.17	3.320	0.13	2.372	0.09
300	4.517	0.18	3.437	0.14	2.455	0.10
320	4.664	0.19	3.549	0.14	2.535	0.10
340	4.808	0.19	3.658	0.15	2.613	0.10
360	4.948	0.20	3.765	0.15	2.689	0.11
380	5.084	0.20	3.868	0.15	2.763	0.11
400	5.216	0.21	3.969	0.16	2.835	0.11
420	5.344	0.21	4.066	0.16	2.904	0.11
440	5.470	0.22	4.162	0.16	2.973	0.12
460	5.593	0.22	4.256	0.17	3.039	0.12
480	5.714	0.22	4.348	0.17	3.105	0.12
500	5.831	0.23	4.437	0.17	3.169	0.12
520	5.946	0.23	4.524	0.18	3.232	0.13
540	6.060	0.24	4.611	0.18	3.293	0.13
560	6.172	0.24	4.696	0.19	3.354	0.13
580	6.280	0.25	4.778	0.19	3.413	0.14
600	6.385	0.25	4.860	0.19	3.472	0.14

NOTE.—The lamp is in its normal position when (the illuminating apparatus or the lenses being vertical) the central foci of the lenses or rings are in the lowest part of the brightest horizontal section of the normal flame. If the sea-horizon had no dip the rays from the lowest part of the brightest section would be sent to the horizon, and the remainder of them distributed over the sea; but the dip of the sea-horizon, when considerable, necessitates some additional elevation in the position of the lamp with reference to the central foci, otherwise many of the brightest rays will be wasted on the sky.

Table II. is given here for the information of Lighthouse authorities who may intend to purchase illuminating apparatus, and points out the necessity of informing the constructors what the height of the light above the water will be. It shows how much the lamp ought to be raised above its normal position (as given in Table I.) owing to the dip of the sea-horizon. Example:—

Illuminating Apparatus, 1st Order, for a Colony.

Height of light above the sea	.. .. .	420 feet
From Table I., we learn that normal distance of burner below the central focus would be	..	1.1 in.
From Table II., we learn that lamp must be elevated above normal position to bring the lowest part of the brightest section to the sea-horizon focus	.. .. .	.2 in.
Corrected distance of burner below central focus	.. .. .	.9 in.

But it must be distinctly understood that if the Lighthouse authorities, when ordering the apparatus, did not inform the constructors what the height of the light above the sea would be, it will not be safe for the former to direct that the lamp be raised the amount of the correction, as by so doing the edge of the burner may cover the foci of one or more of the lower prisms and exclude all light from them. The proper step to be taken is to inform the Lighthouse engineer, or the constructor, and consult him on the subject. In high Lighthouses, if no allowance has been made for the dip, the lower prisms will probably have to be readjusted. One of the best tests of the proper adjustment of the lamp, lenses, and prisms is, for an observer to proceed in a vessel to a distance of some few miles from the Lighthouse, and then with a powerful telescope look at the light: rays should be seen from all the intermediate rings, lenses, or prisms, &c. The light should have the appearance of a narrow vertical beam if it be a fixed light apparatus, and, if revolving, the surface of each holophotal panel should, when turned towards the distant observer, appear throughout its whole extent to be filled with light. If the revolving light be produced by reflectors, then every part of the reflectors should appear filled with light when they are directed to the distant observer. If any of the prisms are out of adjustment, they will show no light.

(f) To ascertain whether the lamp retains its accurate adjustment with regard to the foci, place the eye in rear of burner, and look at opposite band or lens, the image of the horizon (sea) will be seen, raise or lower the focus indicator to the image, or mark its position on a card, then move the indicator or card backwards or forwards until it is found that the image will remain in the same place whether the eye be raised or lowered. This is the position of the sea-horizon focus. Note its height above the burner.

(g) If focus does not plumb centre of apparatus, measure horizontal eccentricity of focus.

(h) Act similarly in regard to the totally reflecting prisms, ascertaining the position with reference to flame and burner of their sea-horizon foci.

(i) The sea horizon focus of the totally reflecting upper prisms should be  $\frac{5}{16}$  of an inch behind the vertical axis of illuminating apparatus, and 1·3 inch above the burner, so as not to waste light on the sky; and for the same reason the focus of the lower prisms should be 1·6 inches in front of the axis, and about  $\frac{9}{16}$  of an inch above the burner.

(k) In the same manner the position of each prism focus can be ascertained and recorded.

(l) Similar directions in regard to the argand burners and the mirrors of catoptric apparatus.

(m) If the focus of the lens is above, or that of prism below, the brighter section of the flame, the best rays will be sent to the sky and wasted; but any attempt at re-adjustment of the lenses should be made only after a consultation with a Lighthouse Engineer.

(n) The foci of the rings in a revolving light, and of the belts in a fixed light, should coincide with the focus of the central lens or band.

(o) The proper position of the foci, with regard to centre of the upper edge of the burner, should be noted on the first page of the journal, so that if the lamp is out of position, it can be readjusted by the Inspector; and any error discovered by the keeper should be instantly reported by him to his superior authority, who should inform the Lighthouse Engineer, who should re-adjust whatever may be out of adjustment.

(p) In hazy weather a false sea-horizon will often mislead the observer. It is therefore advisable that lamps should be adjusted by the sea-horizon only on the brightest and clearest day. In the case of a revolving light, a mark on the land might be used, if there is any sufficiently high and near.

VI. Ascertain if the illuminating apparatus is vertical, by holding a plumb line in centre of upper metallic ring, and see if it passes through centre of apparatus.

In iron lighthouses in the tropics the building may be expected to be unequally affected by the sun's rays, and thrown more or less out of the perpendicular.

When there are reflectors their vertical position may be ascertained by plummet. I visited lately a most important catoptric Lighthouse, lit by nine argand lamps, and ascertained that every lamp had been for many years purposely tilted back from 2 to 3 degrees by the insertion of a small piece of wood under the front part of the lamp, the object being (so the Keeper said) to keep the oil from boiling over. The best rays were of course all sent to the sky.

VII. Ascertain whether the platform is level by placing spirit level in different places.

# I N D E X.

Accidents to apparatus .. ..	Art .. 42	Constructer of lamp .. ..	Art .. 10 c	Gas, light obtained from .. ..	Art .. 37 c
Nature of .. ..	42 d	— of lighthouse .. ..	10	Burners for .. ..	48 a
By whom repaired .. ..	42 a, c	Constructors of dioptric apparatus ..	10 b	Glass of apparatus .. ..	36
Efficiency of repair .. ..	42 f	Consumption of oil .. ..	38 m	— of lantern .. ..	44
Account books, order of .. ..	57 b	How measured for register .. ..	38 l	State of, as to cleanliness	
Adjusting lamps, regulations for ..		Cover for apparatus .. ..	32	and repair .. ..	44 a, b
Op. In. V. e p.		— for lamp and reflector .. ..	48 e	As to colour and substance ..	44 f
Alterations in machinery .. ..	33 f	Cowl of lantern .. ..	46	Scratches observed on .. ..	44 d
If proposed .. ..	33 g	Action of .. ..	46 b	— chimneys .. ..	48 g
Alternating lamps .. ..	29 f	Chimneys for .. ..	47 b	Annual breakage of .. ..	48 h
Apparatus, illuminating, <i>see</i> "Il-		Cross-bars of lantern .. ..	46 c	— lenses or prisms .. ..	75 e
luminating" .. ..		Curtains for interior of lantern ..	44 e	Gongs used as signals .. ..	49 b
Are illuminated by apparatus .. ..	31	Damages, from earthquake or ..		Governing authority of light-	
Argand burner, oil consumed by ..	38 m	storms .. ..	18 e	house .. ..	3
— lamp .. ..	75 f	Damp, how avoided .. ..	17	Guns, use of, as fog signals ..	49 b
Nature of .. ..	48 a	Designer of apparatus .. ..	9	Heating oil, process used ..	38 g
To ascertain focus of .. ..	Op. In. V. l	— of lighthouse .. ..	8	Height of building .. ..	12
Arrangement of lights .. ..	31 e	Destruction occasioned by birds ..	46 c, 75 f	— of centre light .. ..	12 b
Astragals of lantern .. ..	41 h	Diagram of flame .. ..	72 a, 75 f	Above high water .. ..	12 c
Barometer .. ..	55 a	Dioptric apparatus .. ..	25	— of flame to be maintained	
Base of chimney, size of .. ..	48 g	Constructors of .. ..	10 h	Op. In. V. d	
— of lighthouse, how preserved ..	41 c	Height of flame for .. ..	72 a	Hemp rope .. ..	33 b
Bells, for fog signals .. ..	49 b	Oil consumed by .. ..	38 m	Holophotal apparatus .. ..	25
Birds frequenting the neighbour-		Ventilation of .. ..	47 e	Holophotes or reflectors .. ..	28
hood .. ..	67 a	Diseases common to keepers .. ..	60 h	To be covered .. ..	48 e
When appearing and de-		Treatment of .. ..	60 e	Directions for cleaning ..	75 c
parting .. ..	67 e	Draught, prevention of .. ..	47 e	Houses for keepers .. ..	65 a, b
If destructive .. ..	67 b	Duration of fogs .. ..	49 d	Distance from lighthouse ..	65 e
Lamps extinguished by .. ..	46 e	Dwelling-houses .. ..	65	Means of communication	
Boats allowed to keepers .. ..	69 a, b	Expense of erection .. ..	6 b	with .. ..	65 h
Results arising from .. ..	69 c	Lighthouse in sight from ..	65 g	State of road to .. ..	65 f
Brass-work in interior of lantern ..	15 a	Means of communication with ..	65 h	Illuminating apparatus, construc-	
— of lamps, how cleaned .. ..	75 f	Earthquakes, effects of .. ..	18 b	tor of .. ..	10 h
Building of lighthouses .. ..	11	Education of keepers .. ..	62	Cost of erection .. ..	6 b
Colour of building .. ..	15	— of keepers' children .. ..	62 c	Character of .. ..	29
Construction .. ..	17	Efficiency of light .. ..	71	Cleanliness .. ..	56
Exterior .. ..	15 a	Electric currents, light produced		Cover for .. ..	32
Foundation, whether solid or		by .. ..	37 a, 18 a	Designer .. ..	9
made .. ..	16	— lamps .. ..	18 a	Glass for .. ..	36
Height .. ..	12	— telegraph signals .. ..	45	General orderliness of ..	57
Materials used .. ..	11 h, c	Erection of lighthouses .. ..	6 h	Instruments required in ..	55
Painting .. ..	20	Examination of keepers .. ..	62 d	Lamp or lamps used .. ..	48
Ventilation .. ..	19	Expense of building .. ..	6 b	Lantern .. ..	43
Vibration .. ..	18	— of maintenance and re-		Light, how obtained .. ..	37
Burners, how cleaned .. ..	56 h	pairs .. ..	15 d	Machinery .. ..	33
Position of focus in reference		Exterior of lighthouse .. ..	6 a, h	Nature of .. ..	25
to .. ..	Op. In. V. e	Extinguishing lamp .. ..	39, 75 f	Of what order .. ..	26, 27
Capacity of oil store .. ..	21 b	Rules for .. ..	Op. In. IV.	Platform, if level or vertical	
Catadioptric apparatus .. ..	25	If by accident .. ..	41	Op. In. VII.	
Order of, or number of lamps ..	27	Date of .. ..	41 h	Signals for .. ..	49
Catoptric apparatus .. ..	25	Effect of .. ..	41 c	Time of lighting and extin-	
Order of .. ..	28	How frequently .. ..	41 a	guishing .. ..	39
Lamps used in .. ..	18 a	Filtered oil .. ..	21 e, 38 e	Tools required in .. ..	66
Chain or rope of revolving appa-		— water .. ..	58 e	Ventilation .. ..	19, 47
ratus .. ..	33 h	Fire, precautions against, in ..		Weight, how supported ..	34
Time required for replacing ..	57 d	building .. ..	41 h	Imperfect ventilation .. ..	17 a
Character of illuminating appa-		In keeper's house .. ..	65 e	Inland authorities, how commu-	
ratus .. ..	29 a	In oil store .. ..	21 d	nicated with .. ..	51
Children of keepers, education of ..	62 e	Fish caught in the vicinity .. ..	68 a	Inspecting officer, name and rank	
Number of .. ..	64 k	What quantity .. ..	68 b	of .. ..	2
Chimneys, glass, shape of .. ..	48 f	In what month .. ..	68 c	Inspection, intervals of .. ..	7 b
Use and annual breakage of ..	48 h	Fixed lamps .. ..	29 a	Report of, to whom sent ..	7 d
How to remove .. ..	Op. In. II.	— and flashing lamps .. ..	29 e	Scientific portion .. ..	76
— metallic .. ..	47 b, c	— red lamps .. ..	29 i	Inspector .. ..	7
Cleaning of burners .. ..	56 b	Flame .. ..	72	Instruction of keepers .. ..	62 d
— of chimneys .. ..	48 h	Height to be maintained .. ..	71 c, d	Instruments required for light-	
— of glass lenses .. ..	75 e	Diagram of height .. ..	72 a	house .. ..	Op. In. I, 55
— of machinery .. ..	75 i	Management of .. ..	Op. In. V. d	— for cleaning chim-	
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